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THE RADIUM CONTENT OF WATER FROM THE CHINA SEA*

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(*From the Bureau of Science, Manila*)

TWO TEXT FIGURES

The importance of accurate determinations of the radium content of sea water in different parts of the world is just beginning to be fully appreciated. A knowledge of the radium content of the waters of the sea is necessary in a study of such distantly related problems as geological processes and the ionization of the atmosphere with all the consequent questions, such as cloud formation, atmospheric electricity, and transmission of electromagnetic waves around the earth's surface.

Determinations of the radium content of sea water have been made by several investigators, but the determinations have been for the most part limited to the Atlantic Ocean or to the Pacific Ocean in the immediate neighborhood of South America. This is the first record of a determination of the radium content of the water of the China Sea in the vicinity of the Philippines. Throughout this discussion, unless otherwise specified, all results will be expressed in grams $\times 10^{-12}$ per liter of water.

The first attempt to obtain an idea of the amount of radium contained in sea water was made by Strutt,[2] who determined the radium content of a sample of sea salt. His result reduced

* Received for publication October 22, 1917.

[1] Professor of physics, University of the Philippines.

[2] On the distribution of radium in the earth's crust, *Proc. Roy. Soc. London, A* (1907), **78**, 150–153.

to the above unit gives a value of 2.3. This method, however, is open to objection, and the result obtained is rather uncertain, although valuable as showing the order of magnitude of the quantity to be determined.

Eve,[3] in 1907, made a determination of the radium content of Ignau sea salt and also of a sample of sea water from the middle Atlantic and obtained values of 0.3 and 0.6, respectively.

The first extensive series of determinations on sea water was made by Joly[4] in 1908. His method is described as similar to that used by Strutt with the exception that he boiled his sample under a partial vacuum and finally filled with distilled water in order to drive over all the gas containing emanation into his collecting chamber. In the course of his determinations he found that in order to liberate all the emanation generated in the sample within a given time it was necessary to acidify with hydrochloric acid. Especially was this the case with certain samples. This is probably due to the fact that during concentration any precipitates of barium or of sulphates that may form will tend to carry down with them some of the radium and that the emanation is liberated therefrom with difficulty. He also found that his first determination on a given sample generally gave a value considerably lower than subsequent tests. Consequently in making up his mean for any given sample his first determination was omitted. In a later paper[5] Joly gives the results for twenty-five samples from the north Atlantic and Indian Oceans. His highest values were obtained for samples collected off the coast of Ireland, the mean value for five different samples being 34. His lowest value was 2.2 for a sample from the Mediterranean. His mean value for the twenty-five samples is given as 16.

Eve,[6] in 1909, published the results for determinations on six samples of sea water collected at different points in the north Atlantic between Liverpool and Montreal and obtained a value of 0.9 as the mean radium content, the maximum range being from 0.5 to 1.5.

Satterly[7] made several determinations on sea water from

[3] The ionization of the atmosphere over the ocean, *Phil. Mag.* (1907), **13**, 248–258.

[4] The radioactivity of sea-water, ibid. (1908), **15**, 385–393.

[5] On the radium content of sea-water, ibid. (1909), **18**, 396–407.

[6] On the amount of radium present in sea-water, ibid. (1909), **18**, 102–107.

[7] On the radium content of various fresh and sea-waters and some other substances, *Proc. Cam. Phil. Soc.* (1912), **16**, 360–364.

regions near the coast of England. He obtained a mean of 1.0, with a maximum range of 0.2 to 1.6. Contrary to Joly's experience Satterly found that his first determination on any given sample was always higher than succeeding tests and concluded that the most probable result was the mean after the first reading had been eliminated.

Lloyd,[8] in 1915, made three determinations on a sample from the Gulf of Mexico, his mean result being 1.7. Like Joly he also found that the first reading was slightly lower than succeeding ones and consequently omitted it in the determination of his mean value.

On a voyage across the Atlantic from Spain to Chile Knoche [9] made several determinations by what is commonly called the shaking method. The water was collected from the surface in buckets and tested immediately for the emanation content, an Engler and Sieveking electroscope being used. Unfortunately his results are expressed in maches. As a mean of twelve determinations on the Atlantic he obtained 0.12 mache. Joly, in a summary of Knoche's work, attempts to express Knoche's results in terms of the radium content per liter in grams $\times 10^{-12}$ and calculates that 0.12 mache would be equivalent to 17×10^{-12} grams radium per liter, or, expressed in the unit used throughout this discussion, the mean radium content found by Knoche for the Atlantic would be 17. The value for Knoche's mean as given by Joly is probably much too low. The only satisfactory way of converting from the one unit to the other is to make a direct calibration of the particular instrument by introducing a known quantity of radium emanation. For the electroscope with attached ionization chamber that we used in most of our determinations on the radium content of waters, one mache equals 285×10^{-12} grams radium per liter, and on this basis 0.12 mache would be equivalent to 34.6×10^{-12} grams. The conversion factor is dependent, however, on the constants of the particular instrument and varies rapidly with variation in the capacity. The factor that we obtained for our instrument is lower than that given for most instruments, which inclines us to the belief that the mean value of Knoche's results for the Atlantic Ocean, expressed in grams radium, is much higher than that given by Joly. In estimating the value of Knoche's results

[8] The radium content of water from the Gulf of Mexico, *Am. Journ. Sci.* (1915), **189**, 580–582.

[9] Einige Bestimmungen der aktiven Emanation des Meerwassers auf dem Atlantischen Ocean, *Phys. Zeitschr.* (1909), **10**, 157–158.

in terms of grams radium, Joly made certain assumptions, which, as he states, are all on the side of reducing the final result. Knoche [10] has also made something like thirty determinations for a region in the Pacific Ocean off the coast of Chile and obtained a mean value of 0.043 mache.

Mialock [11] has recently made some determinations of the radium content of sea salt in the waters of the Atlantic and Pacific Oceans. We have not been able to obtain access to his original article, and our knowledge of his results is dependent on a brief review appearing in the Chemical Abstracts. His results, however, seem to agree fairly well with those of Knoche.

It is hard to account for the variation in the results of the different investigators. One can easily assume that the radium content varies considerably in different parts of the world, but it is hardly to be expected that there should be a wide variation in any given region. In measuring such minute quantities as the radium in a few liters of sea water, errors in measurement or method are inevitably large, but the large variation noted cannot be accounted for on this basis. In order to get results for widely separated regions that can be directly compared with a fair degree of certainty, it is highly desirable that a standardized method be adopted and even that a uniform type of instrument be used whenever possible.

EXPERIMENTAL RESULTS

Thus far our determinations have been confined to one sample of sea water from the China Sea. The sample was taken from a depth of about 2 meters in the open sea at a distance of approximately 8 kilometers from the entrance to Manila Bay. About forty liters were collected in two large glass bottles, which had been carefully cleaned. Thirty liters were then taken and evaporated to 15 liters on the water bath, pure redistilled hydrochloric acid being added from time to time, so that a slight excess of acid was present during the entire process of concentration. About 25 cubic centimeters of pure hydrochloric acid were then added, and the entire quantity was sealed in a large glass bottle.

[10] Bestimmungen des Emanationgehaltes im Meerwasser und der induzierter Aktivität der Luft zwischen der chilenischen Küste and der Osterinsel, ibid. (1915), **13**, 112–115.

[11] Determination of the radioactive content of the salts in the waters of the Atlantic and Pacific Oceans between Montevideo and El Callao, *Anal. Soc. cient. Argentina* (1915), **79**, 267–275.

Since we were dealing with several times the quantity of sea water used in similar tests by previous investigators, we decided to try the charcoal absorption method. This method is fully described in an article by Wright and Smith [12] on the emanation content of atmospheric air. After the water had remained sealed in the flask for a period of thirty days or longer, the flask was placed in a water bath and heated to about 80° C., when the tips of the tubes leading into the bottle were broken, and emanation-free air was pulled through at the rate of 1 liter per minute. The air was then passed through a bottle containing sulphuric acid and a tube containing calcium chloride and finally through two tubes in series, each of which contained 70 grams of finely granulated coconut charcoal. At the same time air was bubbled through an identical system, except that in place of the bottle containing the sea water there was substituted a small bottle containing 615×10^{-12} grams radium from a standard solution furnished by the Bureau of Standards at Washington, D. C. The portion of solution used had been sealed up, after having been freed from all emanation, for a period of exactly twenty-six and one-half hours, so that the emanation obtained from our standard was equivalent to that in equilibrium with 110.7×10^{-12} grams of radium. Air was bubbled through the boiling solutions until we were certain that all the contained emanation had been transferred to our charcoal tubes. Since in a previous work by Wright and Smith [13] on the quantitative determination of the emanation content of atmospheric air it had been shown that these same charcoal tubes absorb approximately 99 per cent of the emanation passing through them even for much larger quantities of emanation, it was assumed that by this method we would obtain at least as great accuracy as by the more direct method. Moreover this method has the advantage of being a comparative one, so that any errors that are due to inaccuracy of observation will cancel in the final calculations. The arrangement of the apparatus in the collecting system is shown in fig. 1.

After the emanation had been collected in the charcoal tubes, they were heated in an electric furnace, and the gas was driven

[12] The variation with meteorological conditions of the amount of radium emanation in the atmosphere, in the soil gas, and in the air exhaled from the surface of the ground, at Manila, *Phys. Rev.* (1915), n. s. 6, 459–482.

[13] A quantitative determination of the radium emanation in the atmosphere and its variation with altitude and meteorological conditions, *Phil. Journ. Sci., Sec. A* (1914), 9, 51–76.

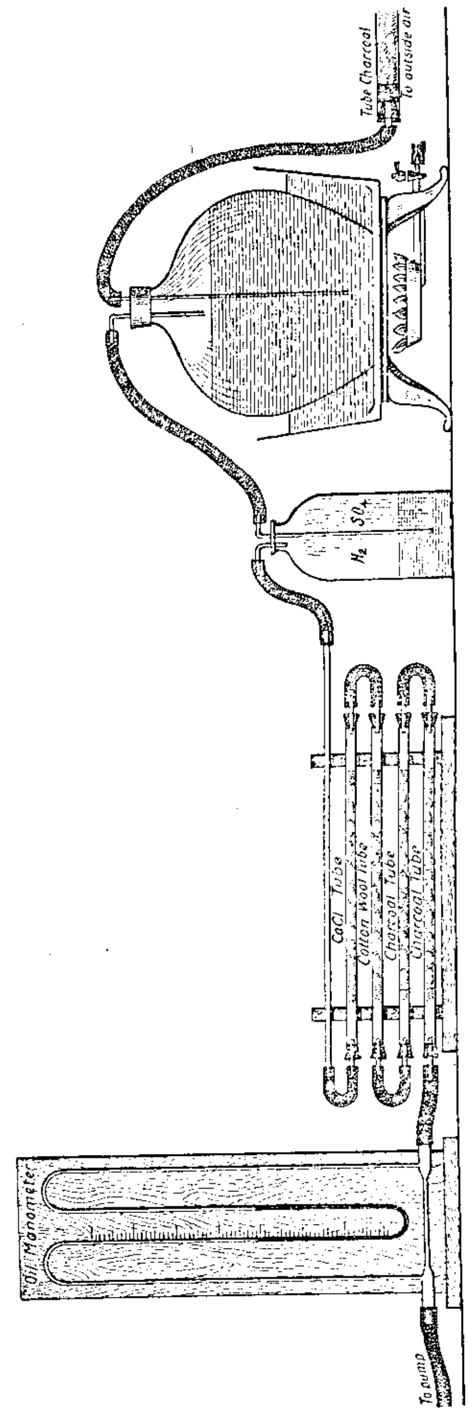

FIG. 1. Apparatus used in charcoal absorption method.

off and collected over water in an aspirator bottle. It was then passed into the ionization chamber of a Spindler and Hoyer electroscope and tested in the usual manner, allowance being made for the decay of emanation in the period elapsing between time of collecting and time of testing. The arrangement of the apparatus in the testing system is shown in fig. 2.

Three separate tests were made by this method. The determinations gave 0.27, 0.16, and 0.17, respectively. The mean of these results is 0.2, a value considerably lower than that obtained by most of the previous investigators. Although the quantity per liter is extremely small, the total quantity, since we were using 30 liters of sea water, was sufficiently large for accurate measurements. On one test the ionization current was observed for four days, and the electroscope readings in volts less the natural leak followed accurately the decay curve for radium emanation, diminishing to one-half value in approximately 3.85 days.

In order to check the charcoal absorption meth-

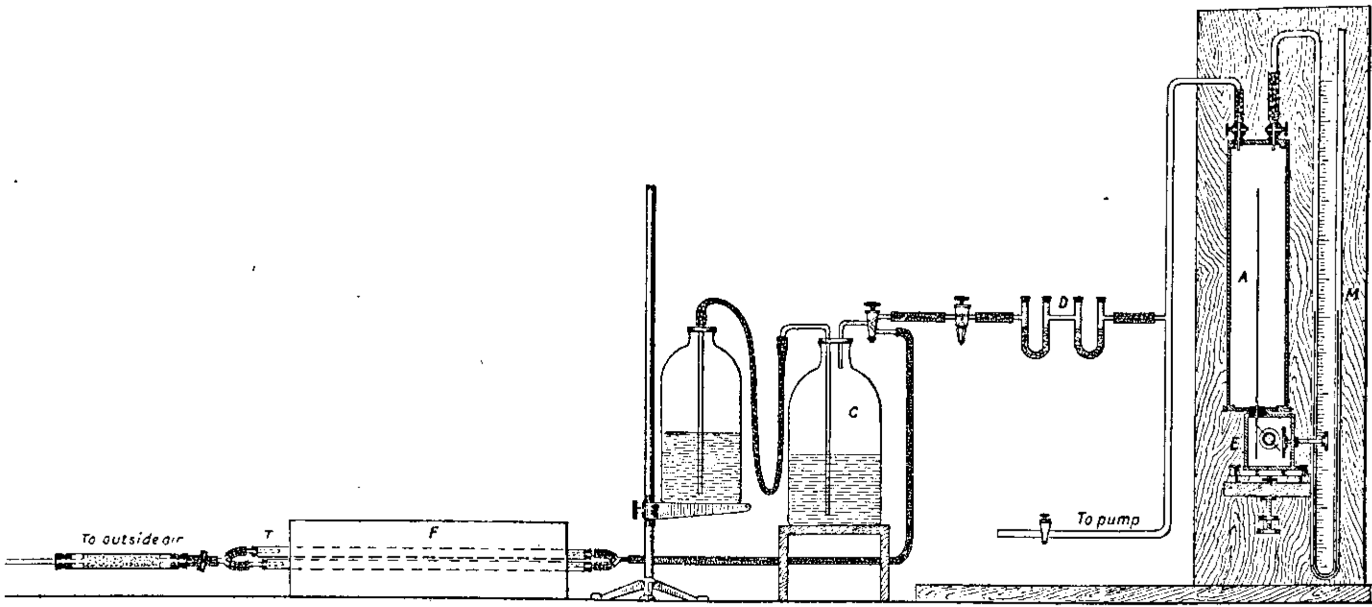

FIG. 2. *A*, ionization chamber; *C*, gas collector; *D*, drying tubes; *E*, electroscope; *F*, electric furnace; *M*, manometer; *T*, charcoal tubes.

od, one direct test was made on the same sample. Previous to sealing up, the sea water was again acidified with approximately 20 cubic centimeters of pure hydrochloric acid. The method used in this test was, as nearly as possible, a duplication of Joly's, the sample being boiled under a partial vacuum and the flask finally filled with distilled water in order to force all the emanation given off into the aspirator bottle. The determination on the activity of the gas was then made in the usual manner, extreme care being taken to flush thoroughly all the tubes between the aspirator bottle and the ionization chamber.

The value obtained by this method was 0.1, or just half the mean value obtained by the charcoal absorption method. In dealing with large quantities of water, we are inclined to believe that the charcoal absorption method will give the more accurate results. In previous work we found that merely boiling a solution from fifteen to twenty minutes was not sufficient to remove all the emanation from even a weak radium solution, but that bubbling air through the boiling solution was much more effective. For this reason, if no other, the charcoal absorption method ought to be slightly more reliable.

Sufficient data are not at present available to permit the drawing of conclusions regarding the radium content of the oceanic waters of this part of the earth compared to such regions as the northern Atlantic Ocean. But in the light of our results determinations from different parts of the Pacific Ocean are much to be desired.

ILLUSTRATIONS

TEXT FIGURES

METHODS OF BURNING POTTERY IN THE VICINITY OF MANILA AND THEIR INFLUENCE ON THE QUALITY OF THE PRODUCT[1]

By J. C. WITT

(*From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila*)

TWO PLATES AND ONE TEXT FIGURE

Throughout the Philippines there are groups of small establishments for the manufacture of clay products in localities in which the necessary raw materials can be easily obtained. Often brick, tile, and pottery of various sorts are manufactured in the same district. Although the small equipment and limited output of the individual manufacturer is likely to give one the impression that the industry is of relatively small importance, the census report[2] shows that even fifteen years ago the annual production was valued at 66,499 pesos.[3] No recent data are available, but the indications are that the output is increasing.

In the potteries in the vicinity of Manila the principal articles manufactured are flower pots (*pasó*), large jars (*bañga*), often used as containers for water or sugar, round-bottomed bowls for cooking rice (*palayok*), and small wood-stoves (*calan*). The raw materials and processes of this district are similar. A clay from the rice fields and a sand from deposits along Pasig River are used. The clay is spread out, allowed to dry, and then pulverized. The sand is passed through a screen made of split bamboo that corresponds to a laboratory sieve having about 8 meshes per centimeter, and the part retained on the screen is rejected. Two parts of clay and one of sand are mixed, water is added, and the material is kneaded to the desired consistency. Apparently there is no uniformity in the time this mixture is allowed to weather. Often some of it is molded the same day it is prepared, while the remainder is allowed to stand until it is all used.

The molding is accomplished by the aid of very crude potter's

[1] Received for publication May 14, 1917.

[2] Census of the Philippine Islands. Government Printing Office, Washington (1905), 4, 522.

[3] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

[4] Cf. Adams and Pratt, *This Journal, Sec. A* (1910), 5, 143.

wheels. These are usually disks of wood about 50 to 75 centimeters in diameter and 8 to 10 centimeters thick. The wheel is given several revolutions by the feet of the potter and thus acquires sufficient inertia to continue in motion for perhaps thirty seconds. Most of the operators are skillful in the use of these wheels, and much of the ware possesses considerable beauty. The molding of some of the articles is completed on the wheel, but the rice bowls are afterward beaten with a flat wooden paddle. This is done to increase the density for the prevention of leakage and to produce walls as thin as is consistent with the necessary strength. I have often seen these pots with walls less than 0.5 centimeter in thickness, and so uniform that the eye could detect no variation.

When the molding is completed, the pottery is allowed to dry in the shade for several weeks and is then burned by one of two methods:

1. A kiln is employed. There are several types. The commonest is long and horizontal and somewhat cylindrical in shape. Wood is the common fuel. As a rule, high temperatures are not obtained in this type of kiln, because of imperfect construction and the quantity of fuel used. However, in some of them the temperature often exceeds 1,200° C.

2. Much of the pottery, especially the rice bowls, is burned without the use of a kiln. The ware is piled on the ground, even in the street, and is covered with straw, pieces of bamboo, rubbish, and the like. After the fuel is fired, it is allowed to burn slowly until all is consumed. The condition of the ware is observed from time to time through small holes in the straw, and when it has reached a dull red heat, the burning is considered finished. The ash and partly burned fuel are gradually removed, and finally the ware is completely uncovered and allowed to cool. This whole operation usually does not require more than an hour or two.

It is largely imperfect burning that has held back the development of Philippine pottery and has prevented a really well-developed technic (in other respects) from producing ware of excellent quality. From tests made in this laboratory, it is apparent that the raw materials used in the district are of satisfactory quality.[5] Experiments have also shown that the proportions in which the two substances are mixed are right and that the methods of molding and drying certain kinds of

[5] See data for clay No. 2, Witt, J. C., *This Journal, Sec. A* (1916), 11, 203.

ware are almost above criticism. However, most of the Philippine ceramic products that I have seen lack strength. This is true of bricks as well as of most pots and jars, and it prevents the manufacture of a really durable product. In the kilns described a few of the articles are burned very well. However, those nearest the fire doors are usually overburned and fuzed out of shape, and many more are not sufficiently burned to develop the maximum strength of the material. The ware manufactured without the use of a kiln is all underburned. This was verified by experiments.

Some of the mixture in daily use at one of the potteries was brought to the laboratory, and several experimental bricks were molded and dried. These were divided into two lots: the first was taken back to the pottery and burned with some ware in the regular way—not in a kiln. A pyrometer was installed, and readings were taken every five minutes during the operation. The other set was burned in an experimental kiln at the Bureau of Science. The temperatures in the latter were determined by Seger cones, because they were too high for the thermocouple.

TABLE I.—*Temperature record of burning in an experimental kiln and in a pile of straw at pottery.*

At pottery.		At pottery.		In experimental kiln.	
Time.	Temperature.	Time.	Temperature.	Time.	Approximate temperature, indicated by cones.
a. m.	°*C.*	*a. m.*	°*C.*	*a. m.*	°*C.*
1.45	30	2.40	355	4.00	[a] 30
1.50	90	2.45	290	*p. m.*	
1.55	250	2.50	240	1.00	970
2.00	515	3.00	200	1.20	1,010
2.05	675	3.05	160	1.45	1,050
2.10	745	3.10	130	2.05	1,090
2.15	755	3.15	110	2.25	1,150
2.20	725	3.20	70	3.25	1,190
2.25	665	3.35	60		
2.30	555	3.30	60		
2.35	450				

[a] Initial temperature.

The temperature-time curves were plotted and are shown in fig. 1, where the contrast in burning operations is readily seen. At the pottery the burning was completed in one hour and thirty-five minutes. The temperature rose to the maximum point, or over 700°, in thirty minutes, and the first stage of the cooling

was almost as rapid. The curve shows that this system does not conform to established methods of burning pottery, which involve heating the ware gradually until the maximum temperature is reached, maintaining that temperature as nearly constant as possible for some time, and then annealing by slow cooling.

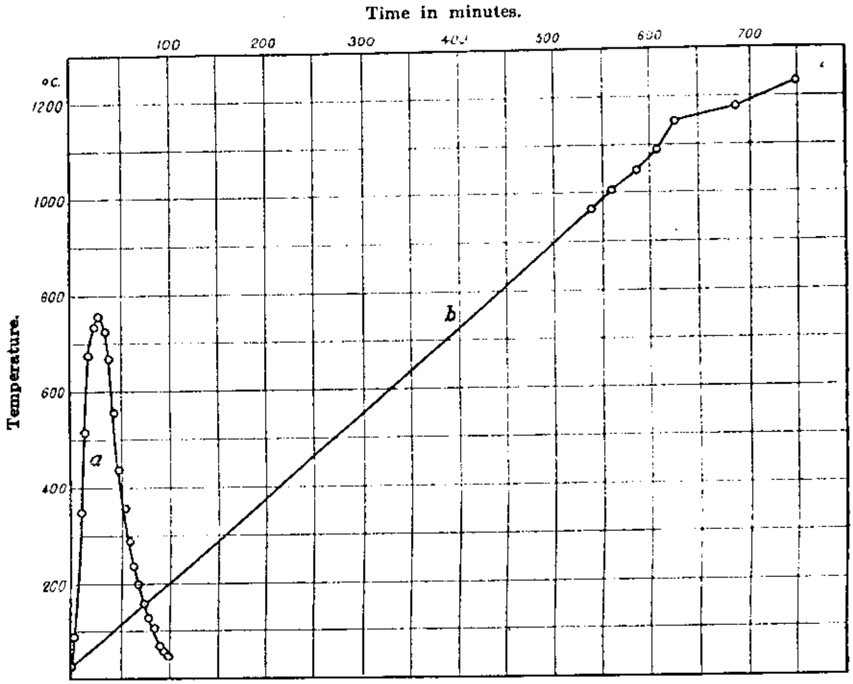

FIG. 1. Rate of burning pottery; *a*, in pile of straw; *b*, in experimental kiln.

The bricks burned at each place were tested for compressive strength.

TABLE II.—*Compressive strength of test bricks.*

Burned at pottery.[a]		Burned in experimental kiln.[b]		
Kilos per square centimeter.	Pounds per square inch.	Approximate temperature.[c]	Kilos per square centimeter.	Pounds per square inch.
		°C.		
252	3,596	1,010	262	3,885
207	2,959	1,050	260	3,709
203	2,896	1,090	261	3,733
223	3,192	1,150	420	5,993
193	2,754	1,190	428	6,118

[a] All bricks were removed at end of operation.
[b] One brick was removed when each cone fused.
[c] Temperatures were determined by Seger cones.

The average compressive strength of the bricks burned at the pottery is 213.6 kilograms per square centimeter, or less than the strength of any one of the specimens burned in the Bureau of Science kiln. While the test at the pottery is a single instance and connot be regarded as an average, the general procedure of burning is always the same, and it is doubtful if results very much higher than these would be ever obtained.

ILLUSTRATIONS

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Fig. 1. Finishing a calan.

Fig. 2. Making a palayok.

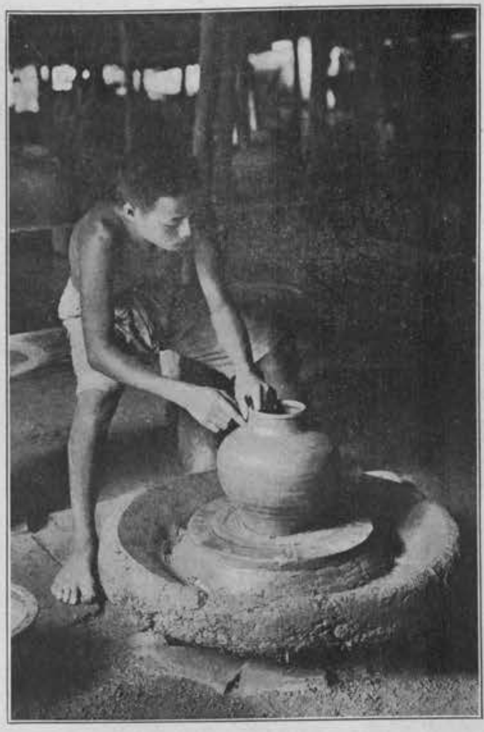

Fig. 3. Shaping a bañga on a potter's wheel.

PLATE I.

Fig. 1. A typical kiln of the Philippines.

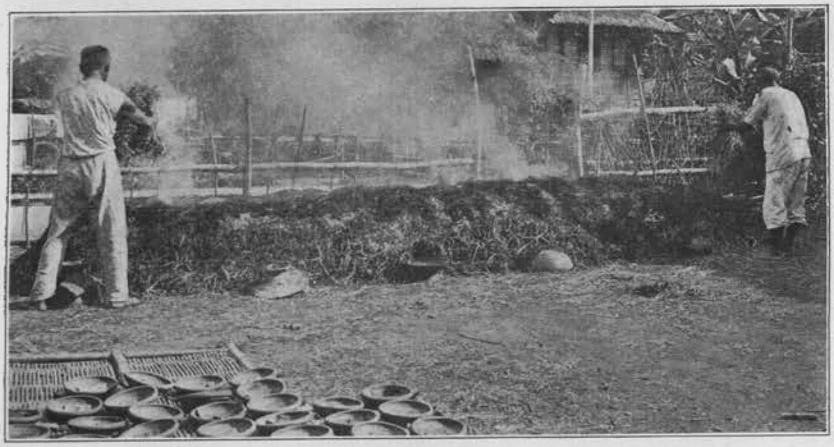

Fig. 2. Burning pottery without the use of a kiln.

Fig. 3. Pottery on sale in Manila market.

PLATE II.

TESTS OF SOME IMPORTED GARDEN LEGUMES

By JOSEPH A. COCANNOUER
(*From the College of Agriculture, University of the Philippines, Los Baños*)

The legumes taken collectively form a part of the diet of most peoples. Of the very large number of plants belonging to the legume family, there are few that possess greater economic importance than do beans and peas. Besides furnishing nourishing food for men and animals, they provide the agriculturist with a means of securing from the store of nitrogen in the air a sufficient amount of this element to replenish that removed by other crops. For this reason these legumes are not only valuable as food crops, but they are of special value when properly used in a garden rotation.

STANDARD LEGUMES OF THE WORLD

Kidney bean (*Phaseolus vulgaris*).—According to de Candolle(5) the kidney bean had its origin in South America. It was unknown in Europe or Asia until the discovery of America. This bean has been excavated from Peruvian tombs in South America and has been found growing wild in several places in the same continent. These are mostly climbing plants, the bush group of *P. vulgaris* having been developed through cultivation and selection. Under each group there are the green and wax pods, but the latter are much less common than the former. The kidneys are the common beans of American and European gardens.

Lima bean (*Phaseolus lunatus*).—For some time the Lima bean was believed to have had its origin in southern Asia.(5) De Candolle never considered that there was any foundation for this belief. Like the kidney bean, the Lima has been excavated from Peruvian tombs and has been found wild along the Amazon. According to de Candolle this bean has never been found wild in any part of the Old World.

The Lima is a rank climbing vine and is divided into two very distinct classes:(4) First, the sieva, which is a slender grower, as compared with the large Lima, and which is comparatively hardy. It is a true annual, producing numerous small papery pods; secondly, the large Lima (var. *macrocarpus*), often called the true Lima, is a tall rank grower, but less hardy than the sieva. The pods are large and fleshy and contain very large flat beans. In the tropics *macrocarpus* is perennial. Bush

types of both classes of Limas have been developed and are rapidly taking the place of the climbing types. These are all annuals.

Lablab or batao (*Dolichos lablab*).—The history of the lablab is rather obscure.(5) It is grown extensively in both Asia and Africa, and de Candolle believed that it grew wild in India. The lablab is cultivated more in southern Asia than perhaps any other legume. The batao is one of the commonest legumes in the Philippines and is found both cultivated and "in a wild state."(8)

The lablab is a glabrous, twining vine whose stems are often purplish. The flowers may be pink, purple, or nearly white. The pods are oblong, wide, and flattened and may be reddish purple, dark green, or white. There are several types,(7) most of the differences occurring in the color and size of the pods.

Cowpea or paayap [*Vigna cylindrica* (*V. unguiculata, V. catjang*)].—While the cowpea is not a true bean, it may be classed with the latter because of the close relationship. It is a native of India(2) and was introduced into America during the latter half of the seventeenth century. In India the cowpea is a rank-growing vine, but in Europe and America the bush types are practically the only ones grown.

The cowpea is readily recognized by its long, slender, cylindrical pods. These are usually pale green, but one (*V. sinensis*) produces red pods.

While the cowpea is a coarse legume, it is usually productive, and the young, tender pods are very palatable if properly prepared. The points in favor of the *Vigna* group are their hardiness and ability to produce a remunerative crop in almost any type of soil.

Sword bean (*Canavalia gladiata*).—Though the sword bean is not a native of the Philippines, four species of the genus, according to Merrill, occur here; *Canavalia gladiata* is the only one considered to be a food legume. MacMillan(7) quotes Firminger as stating that the sword bean is considered by some Europeans to be the "nicest of native vegetables in India."

The edible sword bean (*Canavalia gladiata*) is a climbing vine with very large leaves and flowers. The pods are long, broad, and flat, and each contains several large red beans. The pods are used when young and tender, being cut into slices and used as a vegetable. This bean is supposed to have been described first from Brazil, though there are many species scattered throughout the tropics of the world.

Winged bean or calamismis (*Psophocarpus tetragonolobus*).—The winged bean, according to MacMillan, is a native of Malaysia. It is a glabrous twining vine with light blue flowers. Its pods are square and 4-winged. The crisp, tender pods when properly prepared make one of the best vegetables found in the Philippines. This legume readily produces 150 well-formed pods per plant. The calamismis produces a tuberous root, which is very palatable. In Burma these beans are grown almost entirely for their roots, which yield 2.5 to 4.5 tons per hectare.(7)

Broad bean (*Vicia faba*).—The broad bean is one of the oldest known members of the bean family. It is a native of the Old World,(5) the exact spot of its origin still being questionable. This bean does well only in very cool climates and, so far as I am aware, has never been found a satisfactory legume for tropical gardens. The pods are long and broad, each containing from seven to nine large beans. The broad beans belong to the bush type.

Mungo [*Phaseolus aureus* (*P. mungo*)].—The mungo is a native of India(7) and has been cultivated there as one of the leading food crops as far back as history goes. It is an erect "history" must be a lobster plant and produces narrow, straight, cylindrical pods averaging from 5 to 6 centimeters in length. The entire plant, including the pods, is covered with hairs.

The mungo is common in the Philippines, being one of the crops that can be grown during the time of the year when it is too dry for most other crops. The young pods are sometimes used for food, but it is the dry bean that is especially prized. The beans are prepared as a vegetable in various ways and are very palatable.

Chick pea (*Cicer arietinum*).—The chick pea is an annual plant about 30 centimeters high. The seeds are pealike and angular. This is a common legume in southern Europe and is grown to some extent in India and Ceylon.(7) The chick pea is a favorite legume for use with other vegetables, and in some localities it is very popular, being served in curries.

Pigeon pea (*Cajanus cajan*).—The pigeon pea is a shrub from 1.5 to 2 meters high. It is a native of India,(3) but is now cultivated in most tropical countries. The pods are small and semiflat. Each contains from 2 to 4 smooth, spherical peas. The dry peas are excellent when served as a vegetable or when used in soups and curries.

Garden pea (*Pisum sativum*).—The garden pea, according to de Candolle, is a native of the Old World. It has never been

found in a wild state, and there is considerable disagreement as to whether this pea has been developed from the field pea (*Pisum arvense*) or was distinct in nature. It is believed that the garden pea first existed in a wild state between the Caucasus and Persia. The Aryans are supposed to have first introduced it into Europe.

Garden peas are divided into two very distinct types: the wrinkled and smooth-seeded. The latter are hardier than the former, but on the other hand are considered much inferior in flavor. There are tall and dwarf varieties under each type, the former usually being much later than the latter.

The pea is distinctly a cool-season crop and it is grown extensively in northern Europe and America. However, in India the pea has been acclimatized, until good crops are now secured in that country.

Lentil or lens (*Ervum lens*).—The lentil is the standard legume of both Palestine and Egypt. It is also a leading crop in India during the cool months.(6) The Hindoos consider the lentil the "most nutritious of pulses." The plant is a much-branched, tufted annual, ranging from 30 to 50 centimeters in height. The pods are short, broad, and very flat and contain two flat seeds. The seeds are rounded and convex on both sides. The ancient astronomers named them "telescope glasses," i. e., lenses, because they were shaped like the seeds of *Ervum lens*. The dry seeds are eaten.

Soy bean [*Glycine max* (*G. hispida*)].—The soy bean is a native of China and Japan.(5) It is an erect annual varying from 50 to 100 centimeters or more in height. The pods are short and hairy and contain from 2 to 4 pealike seeds. The seeds vary in color from white to black. These are prepared for food in various ways, being roasted, ground into flour, or boiled. The soy bean contains little or no starch.

Velvet bean (*Mucuna nivea*).—The velvet bean is a strong climber that produces clusters of hairy pods about 6 centimeters long and 1.25 centimeters in diameter. This bean is grown extensively in China, where it probably originated. The pods are either green or black and contain beans that correspond to the pods in color. Each seed is covered by a tough coat, which must be removed before the beans are edible. In China the beans are used extensively for food, and in India both the beans and the young pods are eaten.

Of the fourteen species of legumes discussed, a goodly number are now successfully grown in the Philippines on a commercial scale. These are the Lima, the lablab, the cowpea, the winged

bean, the mungo, and the pigeon pea. Others have been introduced during late years and are now established in a few parts of the Islands. These are the garden pea, the velvet bean, the soy bean, the sword bean, and the kidney bean. The broad bean has received little consideration in the Philippine tropics, but has been given severe tests in other tropics of the world, and so far as I have been able to learn has never been found a success. The lentil also has received little attention in the Philippines, although it is a standard legume in certain other tropical countries. The chick pea is imported into the Philippines in rather large quantities, and several efforts have been made to produce it here, but with little success. While I was in charge of the farm school at Indang, Cavite Province, I made several attempts to grow chick peas, but was never able to secure any crop whatever. The plants grew vigorously and in some cases blossomed freely, but no seed ever developed.

Garden peas are now grown extensively in some localities of the Philippines, and they give promise of soon becoming one of the leading products in several sections. Kidney beans of an excellent quality are also slowly but surely making their way into the local markets. These, too, promise to be extensively propagated on a commercial scale soon. Just how these beans and peas were first introduced is not known. The peas were probably brought in by Chinese market gardeners, and the beans very likely came through the schools.

Of the numerous legume projects carried on by the College of Agriculture during past years, the work with soy beans will probably stand out as being the most valuable. A legume that previously had been considered impossible of culture in the Philippines has been developed through careful study and selection, until it ranks among the most productive legumes grown on the college farm. Other legumes, such as the cowpea, the mungo, and several varieties of Limas, have received special study, and in some cases very encouraging results have been secured.

OBJECT OF THESE EXPERIMENTS

The object of these experiments was twofold: First, to test several varieties of *Phaseolus vulgaris*, *Phaseolus lunatus*, and *Pisum sativum*, which are ranked as "leaders" by American market gardeners, in order to find out whether a profitable yield could be secured from these legumes in the Philippines under ordinary garden conditions and what season or seasons of the year were best suited to their production; secondly, to secure seed for pedigree-selection work with the view of establishing

some of the most promising varieties as garden legumes in the Philippines.

TABLE I.—*List of varieties.*

Variety.	Species.	Group.	Type.	Collection No.
Beans:				
Black Valentine	*Phaseolus vulgaris*	Bush	Green pod	4700
Long Yellow Six Weeks.	do	do	do	4687
Mexican Pink	do	do	do	4938
Longfellow	do	do	do	4695
Extra Early Refugee	do	do	do	4701
Canadian Wonder	do	do	do	4948
French Mohawk	do	do	do	4946
Dwarf Horticultural	do	do	do	4696
Extra Early Red Valentine.	do	do	do	4697
Hodson's Green Pod	do	do	do	4570
Tepary	do	do	do	4945
Michigan White Wax	do	do	Wax pod	4571
Prolific Black Wax	do	do	do	4937
Southern Creaseback	do	Climbing	Green pod	4952
Kentucky Wonder	do	do	do	4685
Lady Washington	do	do	do	4953
Southern Prolific	do	do	do	4769
Henderson's Bush Lima.	*Phaseolus lunatus*	Bush	Sieva	4956
Challenger Lima	do	Climbing	Potato	4957
King of the Garden	do	do	Macrocarpus	4960
Peas:				
Advancer	*Pisum sativum*	Semidwarf	Half-late	6154
Stratagem	do	do	do	6156
Mott's Excelsior	do	Dwarf	Early	6161
Senator	do	Tall	Late	6162
Little Gem	do	Dwarf	Early	6164
Blue Bantam	do	do	do	6159
British Wonder	do	Tall	Late	6364
Yorkshire	do	Semidwarf	Half-late	6157
Extra Early	do	Medium-tall	Early	6152
Laxtonia	do	Semidwarf	do	6357
Alaska	do	Tall	do	6361
Prosperity	do	do	Half-late	6353-a
American Wonder	do	Semidwarf	Early	6153
Little Marvel	do	Dwarf	do	6158
Laxton	do	Tall	do	6149
Alderman	do	do	Late	6354
Abundance	do	Semidwarf	Half-late	6150
Telephone	do	Tall	Late	6151
Champion of England	do	do	do	6360
Large White Marrowfat.	do	Very tall	do	6355
Horsford's Market Garden.	do	Tall	Half-late	6353

All plantings were carried on as projects. The year was divided into three seasons, namely, the cool, which includes October, November, December, and January; the dry season, which includes February, March, April, and part of May; and the wet season, which usually begins about the middle of May and includes June, July, August, and September. Naturally no keen line of demarkation can be drawn between the three seasons, but they are sufficiently well marked as to have distinctly different effects upon plant growth.

PROJECT 1. COOL SEASON

Project 1 was started early in November, 1915. Owing to weather conditions during November, it was not possible to make all of the plantings on the same day. The extremely heavy rains made the replanting of most varieties necessary, and many had to be replanted the second time. However, climatic conditions were so nearly the same during November and part of December, 1915, that the variance in the planting dates probably had little effect on the ultimate results.

The soil on which all of the beans were planted was a heavy clay loam underlaid with a stiff adobe subsoil. The surface soil ranged from 30 to 70 centimeters deep, and owing to the prevalence of cementing materials, it had to be continually stirred to prevent baking. No crop was grown on the land during the previous rainy season. The soil was dug up with the spading fork and then worked into a mellow consistency with the hoe and rake. All plats were 5 by 10 meters, with a 30-centimeter path between the plats. The seeds were planted in rows 70 centimeters apart, and the plants stood 50 centimeters apart, with one plant in the hill, excepting the large Limas, which were planted 1 meter each way. Cultivations were given two or three times each week during the entire growing period.

Table II shows the varieties in order of their rank, which were considered worthy at the first harvest.

TABLE II.—*Varieties, in order of rank, considered worthy of the first harvest.*

Variety.[a]	Rank.	Average pods.	Weight of edible food per plant.	Days from planting till serviceable.	How used.
			Grams.	*Days.*	
Southern Prolific	1	23	146	54	Green.
Henderson's Bush Lima	2	13	21	66	Shell.
Kentucky Wonder	3	20	132	54	Green.
Tepary	4	51	8	61	Dry.
Mexican Pink	5	17	97	53	Green.
Canadian Wonder	6	14	91	40	Do.
Lady Washington	7	15	87	42	Do.
Michigan White Wax	8	20	134	38	Do.
Prolific Black Wax	9	21	140	38	Do.
Southern Creaseback	10	19	118	54	Do.
Extra Early Valentine	11	14	80	40	Do.
Long Yellow Six Weeks	12	7	44	48	Do.
Hodson's Green Pod	13	4	33	69	Do.
Extra Early Refugee	14	5	38	42	Do.

[a] The Black Valentine, the Longfellow, the French Mohawk, the Dwarf Horticultural, the Challenger Lima, and the King of the Garden Lima were almost complete failures. A very few seeds were saved with which to continue the varieties in later projects.

SUMMARY OF PROJECT 1

1. The experiment showed that most of the kidney beans will give a fair yield if the plantings are made during the cool season. With the exception of the last three varieties listed in the table above, the yields were practically equal to what is ordinarily secured from the same varieties in the United States.

2. In some cases there was a marked lessening of the ordinary time from planting until a serviceable product could be secured, while with other varieties the time was not materially changed.

3. Some varieties proved themselves entirely unable to resist the attacks of the leaf hopper and the bean maggot. Some started out vigorously, but soon began to show signs of weakness. A few varieties showed almost no effect of climatic conditions. The varieties of *Phaseolus lunatus* were entirely resistant to the bean maggot and leaf hopper.

PROJECT 2. HOT SEASON

The plantings of the second project were made in the college gardens during March, 1916. The object of this project was to discover what results could be secured by growing beans during the dry season under irrigation. F_1 seed from all of the original varieties was used, and the soil was worked into a "quick" condition as was done in project 1. The seed germinated well, and

when the plants first appeared above ground, they were especially promising.

After about the third day very marked changes could be seen taking place in all of the varieties of *Phaseolus vulgaris*. There was a general yellowing of the leaves, and the small hopper perforated them until they appeared like sieves. The ravages of these insects were materially checked by spraying with a very weak solution of kerosene emulsion. It seemed for a while as if a partial harvest might be secured, but the leaf hopper was no sooner checked than the beans began to show the signs of the bean maggot. Isolated plants died here and there, and within a few days every plant had succumbed. A very special effort was made to save even a few plants of the most promising varieties, but the plats planted to the kidney beans were wiped absolutely bare, and not a seed was saved.

An experiment similar to this was carried on by me at the farm school at Indang, Cavite Province, during the hot months of 1913. The same pests were almost as prominent, and although partial crops were secured, there did not result a profitable yield.

The varieties of *P. lunatus* planted in project 2 were entirely resistant to both the leaf hopper and the bean maggot. The plants grew well from the outset and blossomed freely. There were at first promises of a satisfactory production, but the old habit of shooting the pods was evident as soon as the latter began to appear. The vines grew vigorously during the entire hot season and until they were finally removed in June. Almost no pods reached maturity.

This experiment showed that the growing of kidney beans during the dry season under irrigation is not practicable in this locality.

PROJECT 3. DRY SEASON

Project 3 was carried on in my home garden. Two plats were laid off, each 10 meters wide and of sufficient length to contain twelve varieties of beans, allowing one variety to each row. A 1-meter patch separated the two plats. The land was new and was worked into a mellow consistency by means of spading fork, hoe, and rake. F_1 seed of the following varieties of beans was planted: Tepary, Kentucky Wonder, Canadian Wonder, Henderson's Bush Lima, Mexican Pink, Southern Prolific, French Mohawk, Long Yellow Six Weeks, Prolific Black Wax, Hodson's Green Pod, Michigan White Wax, and Longfellow.

Plat A.—This plat was planted March 11, 1916. The rows

were 50 centimeters apart, and the distance between the hills was 40 centimeters. Two or three seeds were planted in a hill, and when the young plants were well established, they were thinned out so as to leave only one plant in a hill. When the plants were about 5 centimeters high, the plat was covered with a heavy mulch of grass. The mulch was well tamped down with the feet, and special care was taken to see that the grass fitted snugly around the bases of the plants. The mulch was not removed during the entire life of the plants, and naturally the plat was not cultivated after the mulch was put on.

Plat B.—This plat differed from A in that no mulch was used and that the plants received a good cultivation once each week by the hoe. The plants were not irrigated.

Some very interesting facts were brought out in project 3, as the tables will show. Most of the varieties gave a far greater yield in the plat that was mulched than in the unmulched plat. However, it will be noted that a few varieties did not respond with a satisfactory yield in either case. The Limas were severely attacked by the blight and did not mature any pods, although they blossomed profusely.

Perhaps the most noticeable feature connected with project 3 was the great difference between the fruiting seasons of the plants in the two plats. Most of the mulched plants were green and fresh for some time after the plants in the other plat had dried up. Light showers frequently occurred after the plants were fruiting, and these revived those in the unmulched plat, so that they gave a fair, late yield.

There was almost no difference in the sizes of the pods produced in the two plats, and after the weighing of a definite number of pods taken at random, it was necessary to conclude that the mulch increased the number of pods rather than the size.

Neither the bean maggot nor the leaf hopper gave much trouble in project 3, which was radically different from what happened to project 2, which was planted at about the same time. It is believed that this was due rather to the rapidity with which the plants grew than to the absence of the insects. The soil was rich in nitrogen, which soon forced the plants beyond the danger of the pests.

TABLE III.—*Showing effect on plants when plat was covered with a heavy mulch of grass.*

Variety.	Planted.	Flowered.	Served.	Mature.	Average pods.	Maximum pods.	Fifty green pods.	One hundred ripe beans.	Rank.
							Grams.	*Grams.*	
Tepary	March 11	April 9		May 6	44	74		16	9
Kentucky Wonder	do	April 17	April 29	May 20	28	60	440	37	2
Canadian Wonder	do	April 9	April 22	May 13	14	21	340	65	6
Henderson's Bush Lima	do	April 10	(a)						
Mexican Pink	do	April 5	April 26	May 5	23	38	267	32	4
Southern Prolific	do	April 16	April 27	May 14	139	206	330	38	1
French Mohawk	do	April 7	April 19	May 13	7	11	(?)	45	0
Long Yellow Six Weeks	do	April 5	April 22	May 14	16	36	327	33	5
Prolific Black Wax	do	April 7	April 15	May 12	11	24	280	34	8
Hodson's Green Pod	do	April 16	May 25	June 14	5	8	456	24	
Michigan White Wax	do	April 4	April 15	May 7	17	43	336	35	3
Longfellow	do	April 10	April 22	May 11	15	37	320	26	7

[a] Completely destroyed by blight.

TABLE IV.—*Showing growth of plants when no mulch was used.*

Variety.	Planted.	Flowered.	Served.	Mature.	Average pods.	Maximum pods.	Fifty green pods.	One hundred ripe beans.	Rank.
							Grams.	*Grams.*	
Tepary	March 20	April 14		May 11	37	101		14	9
Kentucky Wonder	do	April 17	May 10	June 4	9	20	440	36	5
Canadian Wonder	do	April 20	May 5	June 4	7	8	340	46	8
Henderson's Bush Lima	do	(a)							0
Mexican Pink	do	April 16	April 28	May 21	7	11	267	23	7
Southern Prolific	do	do	May 14	June 22	98	162	330	28	1
French Mohawk	do	April 19	May 8	June 3	5	11	(?)	45	0
Long Yellow Six Weeks	March 22	April 22	May 16	June 5	16	32	327	35	2
Prolific Black Wax	do	do	May 18	June 7	14	27	280	33	4
Hodson Green Pod	do	May 3	May 26	June 8	3	5	456	(?)	0
Michigan White Wax	do	April 20	May 10	June 6	16	27	336	29	3
Longfellow	do	April 23	May 21	June 7	8	17	320	22	6

[a] Completely destroyed by blight.

SUBPROJECT 1. DRY SEASON

At the time of planting of project 3 a subproject was run, which consisted of the planting of 150 square meters of Tepary beans. The plat was located in the college gardens and was prepared by means of spading fork, rake, and hoe. The rows were 70 centimeters apart, and the hills stood 50 centimeters apart with two plants in a hill. The entire plat was cultivated regularly once each week.

The object of subproject 1 was to find out just what production could be secured from Tepary beans grown on a commercial scale during the time when there is little or no rain. The records kept were only those directly related to yield. Promising individual plants were marked, and a careful record was made of the individual production of each of these.

The results secured from this project were very interesting. The plants remained green and continued to produce when even the native beans were suffering for water. No doubt by working with selected individuals the yield of these beans can be very materially increased and the Tepary established as a very valuable dry-weather bean for the Philippines. Experiment has shown that the plants will shoot practically all of their pods during the rainy season, and those that do hang on mature almost no seed.

Very special precautions must be taken in carrying the Tepary beans over from one season to another. Even the slightest moisture will readily cause the beans to lose their vitality. The Tepary is distinctly a dry-weather legume, and the seeds should be dried and sealed during the dry months before the rains begin.

TABLE V.—*Showing the number of pods and the weight of ripe beans secured in subproject.*[a]

Plant No.	Pods.	Ripe beans.	Plant No.	Pods.	Ripe beans.	Plant No.	Pods.	Ripe beans.	Plant No.	Pods.	Ripe beans.
		Grams.			*Grams.*			*Grams.*			*Grams.*
1	27	12.45	6	24	15.11	11	23	11.04	16	25	10.80
2	25	11.26	7	23	11.12	12	29	12.68	17	36	18.62
3	25	10.79	8	26	11.00	13	27	10.03	18	25	11.20
4	28	10.09	9	22	10.07	14	33	15.84	19	31	13.00
5	27	11.04	10	24	12.24	15	21	11.16	20	28	9.93

[a] These yields are about two-thirds of what are secured from the Tepary in southern California.

PROJECT 4. WET SEASON

Project 4 consisted of the plantings of sixteen varieties of beans in the college gardens in a plat 15 meters wide and of

sufficient length to contain all of the varieties. The rows were 70 centimeters apart, and the hills stood 50 centimeters apart with two plants in a hill. The soil was first plowed and then worked into a mellow consistency by means of hoe and rake. The plants were cultivated regularly twice each week. The plantings were made on May 11, 1916, and there was sufficient rain so that irrigation was not necessary. F_1 seed secured from the first plantings was used.

The results obtained from project 4 were disappointing. Only six of the sixteen varieties of beans matured any seed whatever. Neither the Tepary nor the Henderson's Bush Lima produced any pods. Both of these varieties shot their pods when young, because of fungus attacks.

Practically all of the varieties of *P. vulgaris* were severely attacked by the bacterial disease caused by *Pseudomonas phaseoli.* The pole varieties were much more resistant, and a few seeds were saved from a few of those that were apparently free from the disease. It was not possible, however, to save any mature seed from any of the bush varieties. The Hodson's Green Pod, the Longfellow, the Extra Early Refugee, and the Lady Washington all failed because of the attacks from the bean maggot.

The yields were in all cases much below what would be a satisfactory garden production. The Kentucky Wonder, the Canadian Wonder, and the Southern Creaseback gave mediocre yields, but the Southern Prolific came near failing entirely. In most cases there was a slight decrease in the size of pods and in some cases in the size of the ripe bean.

PROJECT 5. WET SEASON

Project 5 consisted of the plantings of fifteen varieties of beans in my home garden, all being *Phaseolus vulgaris.* One row was given to each variety, the rows being 10 meters in length. The rows stood 50 centimeters apart, and the hills were 40 centimeters apart with one plant in a hill. All varieties except two were planted on May 8, 1916, the two exceptions being planted on May 21. F_1 seed secured from the first plantings was used.

Every variety experimented with project 5 started out very promisingly. The bean maggot gave very little trouble, and even with a bacterial disease severely attacking every variety, each gave a fair yield. The disease attacked the pods of all varieties to such an extent that it was practically impossible to secure any ripe seeds whatever.

TABLE VI.—*Data of project 5.*[a]

Variety.	Planted.	Flowered.	Served.	Mature.	Maximum pods.	Average pods.	Rank.
Kentucky Wonder	May 8	June 17	June 28	July 14	15	9	0
French Mohawk	...do	June 7	June 21	July 15	23	12	8
Extra Early Refugee	...do	June 5	June 18	July 13	26	19	3
Extra Early Valentine	...do	June 6	June 15	July 12	44	15	6
Hodson's Green Pod	...do	June 9	June 20	July 14	28	23	0
Canadian Wonder	...do	June 6	June 18	July 13	26	19	4
Mexican Pink	...do	June 5	June 17	July 12	23	12	7
Lady Washington	...do	June 6	June 19	July 11	34	23	1
Dwarf Horticultural	...do	...do	June 18	July 14	29	16	5
Tepary	...do	June 2	(b)				
Southern Prolific	...do	June 19	June 30	July 18	41	21	2
Michigan White Wax	May 21	June 17	June 24	July 20	26	9	9
Longfellow	...do	June 19	July 1	July 15	8	4	0

[a] In ranking the different varieties in project 5, the weight of pods was not recorded because there was still no noticeable change in their size. In the tabulations of the data for this project no weights were recorded, also for this same reason. The amount of edible food material produced for each variety in the different projects will vary as the number of pods.

[b] Plants shot their pods owing to rain.

Table VII aims to show the results from the first plantings made during each of the three seasons: the cool, the hot and dry, and the wet. The original plantings were made during the cool months, and the results secured from these plantings are shown in the first columns. The plantings made during the dry and wet seasons were duplicated, one series being run in the college gardens and one series in my home garden. The dry season plantings in the college gardens were irrigated and cultivated regularly, while those run in the home garden were not cultivated nor irrigated, but were thickly mulched with dry cogon grass. As is shown in the table, the results secured from the mulched cultures for nearly all of the varieties were exceptionally good, while the irrigated crops were a complete failure. Of course, there were features other than heat or moisture that entered in to cause the great difference in the results secured. The soil in the home garden was richer, and although the bean maggot and leaf hopper were present, they were not so numerous as in the college gardens. But notwithstanding these factors, there is a very decided balance on the side of the mulch. The soil is always kept cool and moist, irrespective of how high the temperature above the ground may be. A cool soil is a very essential factor in growing crops during the hot season, and this is not always possible where irrigation is used.

TABLE VII.—*Summary of first planting of beans.*

[0, failure; blank space indicates not run.]

Variety.	Original planting.			Plantings of F1 seed in college gardens.						Plantings of F1 seed in home gardens.					
	November, December, January.			February, March, April, May (irrigated).			June, July, August.			March, April, May (mulched).			June, July, August.		
	Rank.	Average pods.	Days till serviceable.	Rank.	Average pods.	Days till serviceable.	Rank.	Average pods.	Days till serviceable.	Rank.	Average pods.	Days till serviceable.	Rank.	Average pods.	Days till serviceable.
Southern Prolific	1	23	54	0	0	0	3	14	67	1	139	57	2	21	53
Henderson Bush Lima	2	13	66	0	0	0	0	0	0	0	0	0			
Kentucky Wonder	3	20	54	0	0	0	2	16	64	2	28	59		9	51
Tepary	4	51	61				0	0	0	9	44	56	0	[illegible]	0
Mexican Pink	5	17	53	0	0	0	0	3	48	4	23	46	7	12	40
Canadian Wonder	6	14	40	0	0	0	4	14	48	6	14	42	5	19	41
Lady Washington	7	15	42	0	0	0	0	0	0				1	23	42
Michigan White Wax	8	20	38	0	0	0	6	5	47	3	17	35	9	9	34
Prolific Black Wax	9	21	38	0	0	0	5	6	48	8	11	35			
Southern Creaseback	10	19	54	0	0	0	1	17	65						
Extra Early Valentine	11	14	40	0	0	0							6	15	38
Long Yellow Six Weeks	12	7	48	0	0	0	0	4	48	5	16	42			
Hodson's Green Pod	13	4	69	0	0	0	0	0	0	0	0	0	0	8	43
Extra Early Refugee	14	5	42	0	0	0	0	0	0				3	19	41
Dwarf Horticultural	15	7	40	0	0	0	0	4	51				5	16	41
Longfellow	0	5	46	0	0	0	0	0	0	7	15	42	0	4	53
French Mohawk	(a)	(a)	(a)	0	0	0	0	4	48	0	7	39	8	12	44
Black Valentine	0	6	45	0	0	0							4	18	51
King of the Garden	(b)	(b)	(b)	0	0	0	0	0	0						
Challenger Lima	(b)	(b)	(b)	0	0	0	0	0	0						

[a] Almost worthless; few seeds saved.

[b] Very few seeds saved.

Perhaps the strongest point brought out in all of the plantings recorded in this table is the great fluctuation in length of time from planting until the product becomes serviceable for food. Various reasons have been assigned for this. With the plantings made the latter part of May in the college gardens the number of days from planting till serviceable was very materially lengthened for nearly all varieties. This is believed to be due to the fact that after the few light showers in May there was a dry period in June sufficient to check the growth of the plants just before they began to flower. The plants remained in a seemingly dormant condition for several days, when on the arrival of the heavier showers they started into vigorous growth again. While ordinarily dry weather has a tendency to hasten maturity, it seems that in this case a general rule has been broken. It is possible that some other reason may exist, but I have been unable to discover it.

Occasionally the plants will shoot all of the first flowers either because of excessive moisture or disease, and this will materially lengthen the time until the first pods become serviceable.

PROJECT 6–A. WET SEASON

In project 6–A an effort was made to grow the two leading pole varieties of kidney beans, the Kentucky Wonder and the Southern Prolific, in a large plat on a market-garden scale. The soil was first plowed and then worked into a mellow condition by means of hoe and rake. F_1 seed from the original plantings was used, and the hills stood 50 by 70 centimeters apart with two plants in a hill. The plan was to cultivate the plat once each week with the garden cultivator, but the rains were often too severe to permit this.

While the plants in this project started fairly well, much replanting was necessary owing to the bean maggot and other causes, and the final outcome was that not more than 5 per cent of the plants reached the podding stage. Scattered plants here and there gave a fair production, but nothing approaching what would be considered a market-garden yield.

PROJECT 6–B. WET AND COOL SEASONS

Project 6–B consisted of 25 square meters of Kentucky Wonder pole beans planted in the college gardens. F_2 seed harvested from project 3 was used, and the planting was made on August 25, 1916.

The object of this project was to give the Kentucky Wonder a severe test during the time when the rains were heavy. The

soil was prepared as well as practicable under existing conditions, but it was not possible to work it into a mellow state before planting, owing to the excessive moisture. The plat received little cultivation other than keeping down the weeds.

This planting gave rather unexpected results. The average number of pods produced per plant was fifteen, which is low for this variety; yet taking into account the heavy rains and the small amount of cultivation that it was possible to give, the results were satisfactory.

At the same time that this project was run there was also planted a plat each of the Southern Prolific and Southern Creaseback pole beans, but both of these varieties were unable to endure the severe weather conditions and finally succumbed without giving any production whatever.

PROJECT 6–C. COOL SEASON

Project 6–C consisted of a large plat each of the Southern Prolific and Lady Washington pole beans and a small plat of the Long Yellow Six Weeks bush beans, the first two varieties planted on September 2, and the last planted on September 9, 1916. F_2 seed was used, and the hills stood 50 by 70 centimeters apart with one plant in the hill.

The plat of Southern Prolific was more promising at the outset than any planting of this variety previously made. The plants were very uniform, and very few of them succumbed to the ravages of the bean maggot. The vines were strong and vigorous until podding time, when they began to show signs of weakness. What at first promised to be a good production turned out to be a very mediocre one. The plants ceased blossoming after producing the first pods. The maximum number of pods secured from any one plant was twelve with an average per plant of eight pods. This yield was very disappointing and much below what would be expected of this variety.

The Lady Washingtons were much inferior to the Southern Prolifics. A few of the plants struggled along and produced a few green pods, but a bacterial disease caused all of these to drop before maturity, no ripe beans whatever being saved. In some cases the plants died while still producing flowers and pods for no apparent reason. The Lady Washington might be well considered a complete failure in this project.

The Long Yellow Six Weeks did surprisingly well. The plants grew vigorously and gave a fair production. While the number of pods produced was below what would be considered a good yield, yet for this season it could not be considered unsatisfactory.

The maximum number of pods secured from any one plant was eleven, with an average of seven for each plant.

TABLE VIII.—*Data for project 6–C.*

Variety.	Planted.	Flowered.	Serviceable.	Maturity.	Average pods per plant.	Maximum pods per plant.
Southern Prolific	Sept. 2	Oct. 2	Oct. 22	Nov. 10	8	12
Lady Washington	do	Oct. 6	Oct. 16	([a])		
Long Yellow Six Weeks	Sept. 9	Oct. 7	Oct. 20	Nov. 13	7	11

[a] No harvest secured.

PROJECT 6–D. COOL SEASON

Project 6–D consisted of an area of the Henderson's Bush Lima 5 by 7 meters, planted in my home garden on September 2, 1916. F_1 seed from the original planting was used. There was little trouble from the bacterial disease, and even the lightest bearing plants gave a good yield of pods. The maximum number of pods produced on any one plant was forty-two, with an average production of thirty-five pods for each plant. The experiment shows that this is a good bean for this locality, providing it is grown during the cool season. The Henderson's Bush is an early Lima, and even a small area will give a satisfactory production with ordinary care. The yield secured from this variety was practically the same as that secured under ordinary conditions in the United States.

PROJECT 6–E. COOL SEASON

Project 6–E was one of the most satisfactory of the entire set of experiments.

It consisted of the planting of a plat each of the Challenger Pole Lima and the King of the Garden, the latter also a large Lima of the pole type. Both of these plats were planted on August 16, 1916. The King of the Garden became serviceable on November 21, and the Challenger on November 23.

The results of this project were a great contrast to what were secured from the original plantings. All of the plants made a vigorous growth and seemed to adapt themselves to conditions almost as well as the local varieties, which were growing near by. Most of the flowers produced pods that were well filled with large beans conforming in both size and shape to the original seed.

It was not possible to secure an exact production record from either of these plats owing to the fact that the hills and rows stood the same distance apart as is common with such Limas in the United States, and consequently the vines intertwined so

that it was not practicable to count the pods on individual plants. The experiment showed conclusively that the distance between individual plants in the tropics should not be less than 1.25 meters each way.

The King of the Garden proved to be a better yielder than the Challenger. The pods ranged from 10 to 12 centimeters in length and from 2 to 2.5 centimeters in width. Practically every pod contained four large uniform white beans, 2 centimeters wide, 2.25 centimeters long, and about 0.625 (five-eighths) centimeter thick. The pods of the Challenger ranged about 8 centimeters in length and 2.5 centimeters in width, but the bean was considerably thicker than that of the King of the Garden.

Nothing could be more discouraging than these Limas were in the previous plantings. The few seeds that it was possible to save at the first harvest brought forth very unexpected results, and the general condition of the plants left little doubt that both Limas were able to adapt themselves to tropical conditions.

PROJECT 7. COOL SEASON

Project 7 consisted of the plantings of all of the varieties of kidney beans grown at the first planting, excepting those that were run in special projects. F_1 seed secured from the first harvest was used, and all the plantings were made from October 15 to November 6, 1916. This season was very much the same as that of October, November, and December, 1915, the time when the first plantings were made.

Project 7 was run in my home garden rather than in the college gardens for the reason that the soil in the home garden is much richer and mellower than that in any of the college gardens. It was considered essential to give the F_1 seed every opportunity to show what it could do by being planted at exactly the same season as were the original plantings. Those seeds that proved themselves too weak to come through with the best possible care could be hardly expected to withstand a severer treatment.

Unfortunately most of the varieties proved to be weaklings from the beginning, and some of them were very disappointing. Something was expected of the Extra Early Refugee and the Long Yellow Six Weeks, yet they proved themselves unable to endure the slightest adverse conditions. The French Mohawk, the Dwarf Horticultural, the Extra Early Red Valentine, the Hodson's Green Pod, and the Longfellow did not have so much expected of them, and there was consequently little surprise at the results secured. The Red Valentine, however, most unexpectedly gave a fair yield, and was the only one that reached the

podding stage. The maximum number of pods produced on any one plant was thirteen, with an average of four pods per plant. The average was lowered because many plants produced only one or two pods. However, the pods were all of a good size, and the plants were surprisingly vigorous.

Most of the varieties run in project 7 were discarded as being unworthy. The Canadian Wonder, the Extra Early Valentine, and the Long Yellow Six Weeks were considered worthy and were carried further.

PROJECT 8. COOL SEASON

Project 8 was the culminating bean project of the entire series of experiments. It consisted of the plantings of all of the promising varieties of both *Phaseolus vulgaris* and *P. lunatus*. These were the Canadian Wonder, the Long Yellow Six Weeks, the Extra Early Red Valentine, the Black Valentine, the Southern Prolific, the Kentucky Wonder, the Tepary, the Henderson's Bush Lima, the King of the Garden Lima, and the Challenger Pole Lima. In part of the cases F_2 seed was used, and in part F_3 seed was used.

The plantings of this project were made from the middle of November, 1916, to a little beyond the first of January, 1917. The season was cool, with constant light showers during the growth and development of all of the short-lived varieties, no irrigation being required excepting for the varieties that continued to grow well to the middle of March. It was possible to give ideal garden treatment to the cultures at all times, and whatever production was secured was obtained under the most favorable conditions.

TABLE IX.—*Data for project 8.*[a]

Variety.	Planted.	Flowered.	Serviceable.	Seed.	Maximum pods.	Average pods.
Canadian Wonder	Nov. 19	Dec. 14	Dec. 28	F_3	16	6
Long Yellow Six Weeks	do	Dec. 16	Dec. 29	F_3	23	11
Extra Early Red Valentine	Jan. 1	Feb. 2	Feb. 16	F_3	17	9
Tepary	Dec. 10	Jan. 11	Feb. 9	F_3	34	21
Kentucky Wonder	Dec. 24	Jan. 26	Feb. 20	F_3	13	7
Southern Prolific	Jan. 6	Feb. 11	Feb. 24	F_3	36	17
Black Valentine	do	Feb. 10	Feb. 26	F_3	21	11
Henderson's Bush Lima	Dec. 21	Jan. 26	Feb. 22	F_2	29	18
King of the Garden	do	(?)	Mar. 29	F_2	86	27
Challenger	do	(?)	April 3	F_2	108	34

[a] The two large Limas, the Challenger and the King of the Garden, succeeded remarkably well at this planting. The plants were strong and vigorous, there was little sign of disease, and the yield was entirely satisfactory.

TABLE X.—*Summary of successful beans.*

[C, H, W refer to cool, hot, and wet seasons, respectively; O, a failure. A blank space indicates that the variety was not run.]

Variety.	Planting 1.				Planting 2.				Planting 3.			
	When grown.	Days until serviceable.	Average pods.	Rank.	When grown.	Days until serviceable.	Average pods.	Rank.	When grown.	Days until serviceable.	Average pods.	Rank.
Henderson's Bush Lima	C	66	13	2	H	O	O	O	W	O	O	O
Tepary	C	61	51	4	H	56	44	9	W	O	O	O
Southern Prolific	C	54	23	1	H	57	139	1	W	53	21	2
Long Yellow Six Weeks	C	48	7	2	H	42	16	5	W	O	O	O
Extra Early Red Valentine	C	40	14	11	H	O	O	O	W	38	15	6
King of the Garden	C	poor			H	O	O	O	C	95	?	1
Challenger	C	poor			H	O	O	O	C	98	?	2
Black Valentine	C	poor			H	O	O	O	W	44	50	1
Canadian Wonder	C	40	14	6	H	42	14	6	W	41	9	5
Kentucky Wonder	C	54	20	3	H	39	28	2	W	51	9	1

Variety.	Planting 4.				Planting 5.			
	When grown.	Days until serviceable.	Average pods.	Rank.	When grown.	Days until serviceable.	Average pods.	Rank.
Henderson's Bush Lima	C	61	35	1	C	61	18	1
Tepary	C	59	13	1	C	61	21	2
Southern Prolific	C	48	11	1	C	50	17	3
Long Yellow Six Weeks	C	41	7	1	C	40	11	4
Extra Early Red Valentine	C	40	4	1	C	45	9	5
King of the Garden	C	85	?	6				
Challenger	C	90	?	7				
Black Valentine	C	45	7	8	C	51	11	8
Canadian Wonder	C	39	6	7				
Kentucky Wonder	C	66	15	1	C	58	7	10

In most cases the crops ran into two seasons, but the season when the greatest growth and development occurred is the one recorded.

The rank given under each planting refers to the rank that the variety received in the project in which it was run, except the rank given in planting 5. This last rank is the rank held by the variety at the close of the experiments.

PROJECT 9. COOL SEASON

Project 9 consisted of the planting of ten varieties of kidney beans on the same ground and at the same season of the year as the first original plantings. Exactly the same treatment was given these varieties as was given those planted the previous year.

The object of this project was twofold: to check the results

secured from the first plantings with those grown under the same conditions a year later and to compare the yields from a number of new varieties with the yields of the old standard varieties. The old varieties grown as checks on the original plantings were the Tepary, the Extra Early Red Valentine, the Dwarf Horticultural, the Michigan White Wax, and the Southern Creaseback. The new varieties run were those that are considered good yielders by American market gardeners. These were the Golden Wax, the French String, the Improved Rustproof Golden Wax, Morse's Stringless Green Pod, and Burger's Pole.

All of the new varieties gave very satisfactory yields for first plantings. There was little sign of disease of any kind, and the plants made fully as vigorous growths as they would make in the temperate zone. Table XI shows all data secured from this project, together with the average production secured from the first plantings of the five old varieties.

TABLE XI.—*Data for project 9.*

Variety.	Planted.	Flowering.	Serviceable.	Maturity.	Pods.			Collection No.
					Average.	Maximum.	Average first planting.	
Golden Wax	Nov. 17	Dec. 14	Dec. 25	Jan. 23	10	35		6373
French String	do	Dec. 15	Dec. 26	Jan. 24	7	36		6374
Rust Proof Wax	do	Dec. 16	Dec. 27	Jan. 26	8	20		6375
Extra Early Red Valentine.	do	Dec. 17	Dec. 25	Jan. 24	7	18	14	6370
Michigan White Wax	do	Dec. 16	Dec. 24	Jan. 28	6	18	20	6371
Stringless Green Pod	do	Dec. 15	Dec. 25	do	9	37		6376
White Creasebrack	do	Dec. 23	Dec. 30	Jan. 31	17	37	19	6379
Dwarf Horticultural	do	Dec. 15	Dec. 24	Feb. 1	8	35	7	6377
Burger's Pole	do	Dec. 23	Jan. 4	Feb. 6	12	26		6378
Tepary	do	Dec. 15	Jan. 21	Jan. 21	21	77	51	6372

It is interesting to note that of the five old varieties run in this project the Tepary and the Red Valentine gave yields twice as great at the first plantings as were those secured in this project, the Creaseback and the Horticultural gave almost the same production, while the Michigan White Wax gave a yield that was insignificant compared with the first. It would be difficult to assign a reason for these differences in production, owing to the fact that some varieties greatly increased their yields, while others fell back. As stated elsewhere, these last plantings were all made on the same land as were the first plantings and received exactly the same treatment. The seasons were much the

same in both years, although that of 1916–17 was somewhat cooler and more suited to the growing of legumes than was the season of 1915–16.

PEAS: PROJECT 1, DRY SEASON

Project 1 consisted of the plantings of several varieties of garden peas in the college gardens. F_1 seed, produced in 1914 by Mr. José Q. Dacanay, a senior student in the College of Agriculture, was used, and the plantings were made during the latter part of March, 1916. The soil was worked into a mellow condition before planting, and the plants were cultivated and irrigated two or three times each week.

The seeds of practically all of the varieties germinated well, and unlike the beans planted at the same time, there was no trouble from insect pests or fungous diseases. But on the other hand the peas were unable to endure the extreme heat during March and April, and notwithstanding the fact that irrigation was used, the majority of the varieties took on a sickly yellowish appearance and died before blossoming. A few varieties remained alive for a good while and produced a few flowers. An occasional pod was produced, but the pods were not in sufficient abundance to be considered a yield of any sort.

This experiment shows that the garden pea is more easily injured by the tropical heat than are the majority of garden beans. It is probable that the pea will have to be cultivated during the cool months only, if satisfactory results are to be secured.

PEAS: PROJECT 2, WET AND COOL SEASONS

Project 2 consisted of the planting of eighteen varieties of peas in my home garden, the plantings being made on September 30, 1916. The varieties were selected so as to include those most popular with American market gardeners and were the following: Prosperity, Alaska, Blue Bantam, American Wonder, British Wonder, Extra Early, Laxtonian, Little Marvel, Mott's Excelsior, Little Gem, Thomas Laxton, Alderman, Abundance, Advancer, Senator, Telephone, Stratagem, and Yorkshire. The plats were arranged side by side, and each plat contained about 10 square meters. The peas were given the same treatment that they are commonly given in the temperate zone, that is, the rows standing about 50 centimeters apart and the seeds drilled thickly in the row.

The heavy rains during October and November proved disastrous, and in spite of the fact that the very best care was given the plants, very few of the varieties produced any crop worth mentioning. The following were complete failures: Alderman, Advancer, Alaska, Stratagem, Telephone, Extra Early, American Wonder, Abundance, Little Marvel, Senator, Little Gem, British Wonder, Blue Bantam, Yorkshire, and Mott's Excelsior. A very few seeds were saved from the Laxtonian and the Thomas Laxton, but not a sufficient quantity to be called a harvest. I believe that the results secured from this project are sufficiently conclusive to show that the pea is unsuited to a season when the rains are heavy.

PEAS: PROJECT 3, COOL SEASON

Project 3 consisted of the original plantings of twenty varieties of garden peas in my home garden. The plantings were made during November and December, 1916, and consisted of the following varieties: Laxtonian, Little Marvel, Mott's Excelsior, Prosperity, Thomas Laxton, Alaska, Blue Bantam, American Wonder, British Wonder, Extra Early, Alderman, Abundance, Advancer, Senator, Stratagem, Horsford's Market Garden, Champion of England, Telephone, Yorkshire Hero, and Large White Marrowfat.

This project gave an excellent opportunity to find out just what each variety of pea would do under good conditions. There was not too much rain, and the atmosphere was cool and moist during the entire growing period of all of the varieties, excepting a few of the latest. The soil was kept in good condition, and good garden treatment was given at all times.

But in spite of the good weather conditions and the excellent care given, most of the varieties proved unsatisfactory. These were in almost all cases the dwarf, early varieties. The following varieties succeeded and were promising at all times: Champion of England (tall and late), Senator (tall and late), Alderman (tall and late), Prosperity (tall and medium early), Stratagem (semidwarf and half-late), American Wonder (semidwarf and early), Thomas Laxton (tall and early), Large White Marrowfat (very tall and late), Horsford's Market Garden (tall and half-late), Alaska (tall and early), Extra Early (medium-tall and early), and Laxtonian (medium dwarf and early). Table XII shows the data secured.

TABLE XII.—*Data for project 3.*

Variety.	Planted.	Serviceable.	Average pods.	Maximum pods.	Average peas per pods.
Champion of England	Nov. 19	Jan. 22	4	6	4
Senator	do	Jan. 26	4	11	3.4
Alderman	do	do	5.6	7	4
Prosperity	Nov. 8	Dec. 16	1	2	1.4
Stratagem	do	Dec. 15	1.6	2	2
American Wonder	do	Dec. 13	1.6	2	1.8
Thomas Laxton	do	do	1.3	2	1.5
Large White Marrowfat	Dec. 19	Feb. 26	7	12	4.3
Horsford's Market Garden	do	Feb. 22	5	11	4
Alaska	Nov. 2	Feb. 4	1	2	2
Extra Early	do	do	1.4	3	2.2
Laxtonian	do	do	1	2	3

All of the tall, late varieties gave a fair yield. If the plants had not stood so close together in the row (the distance between plants being about 6 centimeters), no doubt the average production for each plant would have been materially greater. The Senator, the Alderman, the Marrowfat, and the Horsford's Market Garden produced very strong, vigorous vines that left little doubt as to their being able to adapt themselves to tropical conditions. The results of the first plantings were such as to leave no doubt that the tall late varieties are the ones to be developed for the tropical garden.

PEAS: PROJECT 4, COOL SEASON

Project 4 consisted of the plantings of F_1 seed secured from several varieties, mostly early, run in project 2. All of these plantings were made in January; they consisted of the following varieties: Alaska, Extra Early, Laxtonian, Prosperity, Stratagem, American Wonder, and Thomas Laxton.

It was possible to notice a slight difference in the hardiness of all of these varieties at the second planting, but this was probably due to the favorable weather conditions more than to any other one thing. However, there was one variety, the Stratagem, which in vigorous growth and general hardiness stood so far superior to all neighboring varieties that it was easily noticeable at some distance. The leaves and the stems remained dark green for some time after the weaker varieties had succumbed. The Stratagem did not continue to blossom and produce pods longer than those in the neighboring plats, but its ability to resist the heat and to grow vigorously for some time after the first

pods became serviceable was sufficient to give it an acceptable rank. The pods were fully a third larger than those secured at the first planting and were well formed. The plants were semidwarf, and the stems and leaves were thicker and sturdier than even the very late varieties.

Table XIII shows the data secured from this planting, with a repetition of the yields made from the first planting.

TABLE XIII.—*Data for project 4.*

Variety.	Planted.	Serviceable.	Maximum pods.		Average pods.	
			First planting.	Second planting.	First planting.	Second planting.
Alaska	Jan. 1	Feb. 3	2	3	1	2
Extra Early	do	do	3	4	1.4	2.6
Laxtonian	do	do	2	3	1	1.8
Prosperity	Jan. 14	Feb. 23	2	4	1	1.5
Stratagem	do	do	2	4	1.6	2.5
American Wonder	do	Feb. 21	2	3	1.6	2
Thomas Laxton	do	do	2	3	1.3	1.5

While the data secured from these various plantings of peas are in no sense conclusive—nor are they intended to be so—they are suggestive of possibilities.

In plant-breeding experiments and acclimatization trials a certain variety of plants will turn out almost a complete failure at the first planting and then burst forth with amazing success from the plantings of the F_1 seed; on the other hand, a success at the first planting is not a guarantee of future successes. No doubt the strong, vigorous plant at the first planting has many advantages over the weaklings. The object of this paper was not necessarily to find out whether or not peas would grow in the tropics, for this problem has been conclusively solved for the tropics of America, India, Ceylon, and other points of the East Indies and also conclusively for the Philippines; the object was rather to discover if possible which types and varieties of peas would respond most readily to the climatic conditions in the Philippines and, as stated elsewhere, to secure foundation stock for individual selection work. From more than twenty varieties we have found five that are more or less promising, which will be run in future cultures with the object of establishing them in the Islands. These are the Stratagem, the Senator, Horsford's Market Garden, the Large White Marrowfat, and the Alderman.

SUMMARY AND CONCLUSIONS

From the data we summarize and draw the following conclusions:

1. Kidney beans (*Phaseolus vulgaris*) will usually give a satisfactory yield from newly introduced seed if planted during the cool season.

2. Seeds of the kidney bean lose their vitality readily in the tropics; consequently all seeds should be thoroughly dried and sealed in order to preserve this vitality. Only seeds that are strongly vital will ever be able to resist the attacks of the bean maggot, the worst enemy of the growing of kidney beans in the Philippine Islands.

3. The growing of kidney beans during the dry hot months even under irrigation is not likely to prove worth while. The plants are too tender to endure the intense heat that is reflected from the hot soil during parts of the day.

4. Rich soil, thickly mulched, will produce a fair crop of kidney beans in this locality even during the hotter months.

5. The number of days from planting beans until the crop is serviceable will vary with the different seasons.

6. There is a close correlation between production and the vigor of kidney beans.

7. The bush group of kidney beans is more subject to the bacterial disease caused by *Pseudomonas phaseoli* during the rainy season than is the pole group.

8. The kidney beans, as a general rule, are not suited to the rainy season. Either bacterial disease or the tendency to shoot the pods, owing to excessive moisture, will render the crop too small to come within the bounds of economy.

9. Lima beans (*Phaseolus lunatus*) are likely to be less promising at the first planting than are the kidney beans. However, F_1 seed is likely to respond with a favorable production.

10. The Limas are entirely resistant to the bean maggot.

11. Pole Limas have the tendency to take on the perennial habit in the tropics. Individual plants should be trained on trellises 1.25 meters each way for best results.

12. The Limas require much less care than do the kidney beans. They will yield fairly well during the rainy season and may be made to produce crops during the dry season with slight irrigation. However, plants grown during the cooler months will give the best results.

13. There appears to be no correlation between the production and the vigor of peas.

14. A strong, vigorous variety of peas will produce a strong, vigorous growth from the F_1 seed if grown under the same conditions.

15. Peas are not suited either to the dry season or to the wet season.

16. Peas are little affected by insects or fungous pests if grown during the cool months.

17. The tall late varieties respond more favorably to tropical conditions than do the early dwarfs.

18. Peas do not seem to lose their vitality as readily as beans, yet the seeds should be thoroughly dried and sealed in order to have them as vital as possible at planting time.

In the preparation of this work I received valuable aid and suggestions from Dr. E. B. Copeland, dean of the College of Agriculture; Dr. F. W. Foxworthy, associate professor of dendrology and chief of the School of Forestry; and Prof. C. F. Baker, chief of the department of agronomy.

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REVIEWS

Preliminary | mathematics | by | Prof. F. E. Austin, B. S., E. E. | Hanover, N. H. | [7 lines]. | Copyright 1917, pp. 1-169—i-iv. Cloth, price $1.20.

In the introduction the author seems to be greatly in favor of the English system of units and tries to show that it is more convenient to use it than the metric system. This question of units has been thoroughly discussed by engineers and scientists for some time in the past, and each system has its own followers.

The subject matter in the book is arranged in the most logical order, and the practical applications of the theories discussed are clearly shown.

The problems and examples seem carefully chosen and well worked out and should furnish a guide to students who are beginning to study algebra to enable them to develop the process of correct and logical thinking.

The book will prove valuable to students and teachers and will be a great help for those intending to take examinations in algebra.

As a whole, the book admirably responds to the purpose for which it is intended, and its use is greatly recommended.

F. V. VALENCIA.

The Application of | Physico-Chemical | Theory to technical processes and | manufacturing methods, | by | Prof. Dr. R. Kremann | (Graz) | Translated from the German by | Harold E. Potts | M. Sc. (Liverpool) | and | edited by Albert Mond, Ph. D. | [ornament] | New York | D. Van Nostrand Company | Twenty-five Park Place | 1915 | Pp. i-xv—1-212. Cloth, price, $2.50 net.

"Physical chemistry used to be considered a somewhat theoretical branch of study, but it has recently developed in such a way as to explain many of the empirical observations of technology and to prove extremely suggestive of many new methods, etc."

Besides the discussion of theory the author has taken up the special topics of: The ideal efficiency of the steam engine; the gas engine; producer gas; water gas; colloidal solutions; the catalytic action of ferments; the drying of linseed oil; vitrification and devitrification; the Deacon process; the contact pro-

cess for sulphuric acid; the manufacture of nitric acid and ether; the manufacture of soap; the caustification of sodium carbonate with alkaline earths; lime burning; Nordhäusen sulphuric acid; roasting lead; the Pattinson process; the iron-reducing method and the formation of matte; nickel matte; puddling; plaster of Paris; the setting and hardening of Portland cement; the weathering of clay; dyeing; vulcanization of rubber; the Parkes process; the ammonia-soda process; the formation of saltpeter from Chile saltpeter and potash.

The book has been well reviewed in the Journal of the American Chemical Society (1914), 36, 1065, and in the Journal of Physical Chemistry (1914), 18, 457.

The author has covered a great deal of ground and, in general, very well, and the book will greatly aid in making a closer connection between physical and industrial chemistry.

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